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(54) Omniview motionless camera orientation system

RUNDUMSICHTAUSRICHTUNGSSYSTEM MIT BEWEGUNGSLOSER KAMERA

SYSTEME D'ORIENTATION DE CAMERA IMMOBILE A VISUALISATION OMNIDIRECTIONNELLE

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- **PATENT ABSTRACTS OF JAPAN vol. 014, no. 362 (E-0960), 6 August 1990 (1990-08-06) -& JP 02 127877 A (CASIO COMPUT CO LTD), 16 May 1990 (1990-05-16)**
- **LIPPMANN, A., "Movie Maps: An Application of the Optical Videodisc to Computer Graphics", Siggraph Conference Proceedings (1980), pages 32 to 42**

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Description

TECHNICAL FIELD

[0001] The invention relates to an apparatus, algorithm, and method for transforming a hemispherical field-of-view image into a non-distorted, normal perspective image at any orientation, rotation, and magnification within the field-of-view. The viewing direction, orientation, and magnification are controlled by either computer or remote control means. More particularly, this apparatus is the electronic equivalent of a mechanical pan, tilt, zoom, and rotation camera viewing system with no moving mechanisms.

BACKGROUND ART

[0002] Camera viewing systems are utilized in abundance for surveillance, inspection, security, and remote sensing. Remote viewing is critical for robotic manipulation tasks. Close viewing is necessary for detailed manipulation tasks while wide-angle viewing aids positioning of the robotic system to avoid collisions with the work space. The majority of these systems use either a fixed-mount camera with a limited viewing field, or they utilize mechanical pan-and-tilt platforms and mechanized zoom lenses to orient the camera and magnify its image. In the applications where orientation of the camera and magnification of its image are required, the mechanical solution is large and can subtend a significant volume making the viewing system difficult to conceal or use in close quarters. Several cameras are usually necessary to provide wide-angle viewing of the work space.
[0003] In order to provide a maximum amount of viewing coverage or subtended angle, mechanical pan/tilt mechanisms usually use motorized drives and gear mechanisms to manipulate the vertical and horizontal orientation. An example of such a device is shown in U.S. Patent Number 4,728,839 issued to J.B. Coughlan, et al, on March 1, 1988. Collisions with the working environment caused by these mechanical pan/tilt orientation mechanisms can damage both the camera and the work space and impede the remote handling operation. Simultaneously, viewing in said remote environments is extremely important to the performance of inspection and manipulation activities.
[0004] Camera viewing systems that use internal optics to provide wide viewing angles shave also been developed in order to minimize the size and volume of the camera and the intrusion into the viewing area. These systems rely on the movement of either a mirror or prism to change the tilt-angle of orientation and provide mechanical rotation of the entire camera to change the pitch angle of orientation. Using this means, the size of the camera orientation system can be minimized, but "blind spats" In the center of the view result. Also, these systems typically have no means of magnifying the image and or producing multiple images from a single camera.
[0005] JP-02-127877A of Casio describes a system for correcting the distortion in any of nine predefined regions of an image captured by a fish eye lens. Distortion data used for the correction is pre-stored in memory.
[0006] EP-A-0111909 describes another picture processing apparatus for correcting a distorted picture captured by a wide angle lens.
[0007] WO 8203712A describes a system for transforming an image. Input commands designating X and Y pre-translation, X and Y size control, Z axis rotation and X and Y post-translation are received and used to generate a composite transformation factored into horizontal and vertical components which are applied to the image.
[0008] In the paper 'Movie Maps: An Application of the Optical Video Disc to Computer Graphics' (Siggraph conference proceedings, 1980, pages 32 to 42), LIPPMAN A. describes a videodisc system which manipulates stored images to enable a user to experience a simulated 'drive' through a space.
[0009] Accordingly, it is an abject of the present invention to provide an apparatus that can provide an image of any portion of the viewing space within a hemispherical field-of-view without moving the apparatus.
[0010] It is another object of the present invention to provide horizontal orientation (pan) of the viewing direction with no moving mechanisms.
[0011] It is another object of the present invention to provide vertical orientation (tilt) of the viewing direction with no moving mechanisms.
[0012] It is another object of the present invention to provide rotational orientation (rotation) of the viewing direction with no moving mechanisms.
[0013] It is another object of the present invention to provide the ability to magnify or scale the image (zoom in and out) electronically.
[0014] It is another object of the present invention to provide electronic control of the image intensity (iris level)
[0015] It is another abject of the present invention to be able to change the image intensity (iris level) without any mechanisms.
[0016] It is another object of the present invention to be able to accomplish said pan, tilt, zoom, rotation, and iris with simple inputs made by a lay person from a joystick, keyboard controller, or computer controlled means.
[0017] It is also an object of the present invention to provide accurate control of the absolute viewing direction and

orientations using said input devices.

[0018] A further object of the present invention is to provide the ability to produce multiple images with different orientations and magnifications simultaneously.

[0019] Another object of the present invention is to be able to provide these images at real-time video rates, that is 30 transformed images per second, and to support various display format standards such as the National Television Standards Committee RS-170 display format.

[0020] These and other objects of the present invention will become apparent upon consideration of the drawings hereinafter in combination with a complete description thereof.

DISCLOSURE OF THE INVENTION

[0021] The present invention provides a system as set forth in claim 1 and a method as set forth in claim 13.

[0022] In one preferred embodiment, the incoming image is produced by a fisheye lens which has a hemispherical field-of-view. This hemispherical field-of-view image is captured into an electronic memory buffer. A portion of the captured image containing a region-of-interest is transformed into a perspective correct image by image processing computer means. The image processing computer provides direct mapping of the hemispherical image region-of-interest into a corrected image using an orthogonal set of transformation algorithms. The viewing orientation is designated by a command signal generated by either a human operator or computerized input. The transformed image is deposited in a second electronic memory buffer where it is then manipulated to produce the output image as requested by the command signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

FIG. 1 shows a schematic block diagram of the present invention illustrating the major components thereof.

FIG. 2 is an example sketch of a typical fisheye image used as input by the present invention.

FIG. 3 is an example sketch of the output image after correction for a desired image orientation and magnification within the original image.

FIG. 4 is a schematic diagram of the fundamental geometry that the present invention embodies to accomplish the image transformation.

FIG. 5 is a schematic diagram demonstrating the projection of the object plane and position vector into image plane coordinates.

BEST MODE FOR CARRYING OUT THE INVENTION

[0024] In order to minimize the size of the camera orientation system while maintaining the ability to zoom, a camera orientation system that utilizes electronic image transformations rather than mechanisms was developed. While numerous patents on mechanical pan-and-tilt systems have been filed, no approach using strictly electronic transforms and fisheye optics has ever been successfully implemented prior to this effort. In addition, the electro-optical approach utilized in the present invention allows multiple images to be extracted from the output of a single camera. Motivation for this device came from viewing system requirements in remote handling applications where the operating envelop of the equipment is a significant constraint to task accomplishment.

[0025] The principles of the present invention can be understood by reference to FIG. 1. Shown schematically at 1 is the fisheye lens that provides an image of the environment with a 180 degree field-of-view. The fisheye lens is attached to a camera 2 which converts the optical image into an electrical signal. These signals are then digitized electronically 3 and stored in an image buffer 4 within the present invention. An image processing system consisting of an X-MAP and a Y-MAP processor shown as 6 and 7, respectively, performs the two-dimensional transform mapping. The image transform processors are controlled by the microcomputer and control interface 5. The microcomputer control interface provides initialization and transform parameter calculation for the system. The control interface also determines the desired transformation coefficients based on orientation angle, magnification, rotation, and light sensitivity input from an input means such as a joystick controller 12 or computer input means 13. The transformed image is filtered by a 2-dimensional convolution filter 8 and the output of the filtered image is stored in an output image buffer 9. The output image buffer 9 is scanned out by display electronics 10 to a video display device 11 for viewing.

[0026] A range of lens types can be accommodated to support various fields of view. The lens optics 1 correspond directly with the mathematical coefficients used with the X-MAP and Y-MAP processors 6 and 7 to transform the image. The capability to pan and tilt the output image remains even though a different maximum field of view is provided with a different lens element.

[0027] The invention can be realized by proper combination of a number of optical and electronic devices. The fisheye lens 1 is exemplified by any of a series of wide angle lenses from, for example, Nikon, particularly the 8mm F2.8. Any video source 2 and image capturing device 3 that converts the optical image into electronic memory can serve, as the input for the invention such as a Videk Digital Camera interfaced with Texas Instrument's TMS 34061 integrated circuits. Input and output image buffers 4 and 9 can be constructed using Texas Instrument TMS44C251 video random access memory chips or their equivalents. The control interface can be accomplished with any of a number of microcontrollers including the Intel 80C196. The X-MAP and Y-MAP transform processors 6 and 7 and image filtering 8 can be accomplished with application specific integrated circuits or other means as will be known to persons skilled in the art. The display driver can also be accomplished with integrated circuits such as the Texas Instruments TMS34061. The output video signal can be of the NTSC RS-170, for example, compatible with most commercial television displays in the United States. Remote control 12 and computer control 13 are accomplished via readily available switches and/or computer systems that also will be well known. These components function as a system to select a portion of the input image (fisheye or wide angle) and then mathematically transform the image to provide the proper prospective for output. The keys to the success of the invention include:

(1) the entire input image need not be transformed, only the portion of interest
(2) the required mathematical transform is predictable based on the lens characteristics.

[0028] The transformation that occurs between the input memory buffer 4 and the output memory buffer 9, as controlled by the two coordinated transformation circuits 6 and 7, is better understood by looking at FIG. 2 and FIG. 3. The image shown in FIG. 2 is a pen and ink rendering of the image of a grid pattern produced by a fisheye lens. This image has a field-of-view of 180 degrees and shows the contents of the environment throughout an entire hemisphere. Notice that the resulting image in FIG. 2 is significantly distorted relative to human perception. Vertical grid lines in the environment appear in the image plane as 14a, 14b, and 14c. Horizontal grid lines in the the envimoment appear in the image plane as 15a, 15b, and 15c. The image of an object is exemplified by 16. A portion of the image in FIG. 2 has been correct, magnified, and rotated to produce the image shown in FIG. 3. Item 17 shows the corrected representation of the object in the output display. The results shown in the image in FIG. 3 can be produced from any portion of the image of FIG. 2 using the present invention. Note the corrected perspective as demonstrated by the straightening of the grid pattern displayed in FIG. 3. In the present invention, these transformations can be performed at real-time video rates (30 times per second), compatible with commercial video standards.

[0029] The invention as described has the capability to pan and tilt the output image through the entire field of view of the lens element by changing the input means, e.g. the joystick or computer, to the controller. This allows a large area to be scanned for information as can be useful in security and surveillance applications. The image can also be rotated through 360 degrees on its axis changing the perceived vertical of the displayed image. This capability provides the ability to align the vertical image with the gravity vector to maintain a proper perspective in the image display regardless of the pan or tilt angle of the image. The invention also supports modifications in the magnification used to display the output image. This is commensurate with a zoom function that allows a change in the field of view of the output image. This function is extremely useful for inspection operations. The magnitude of zoom provided is a function of the resolution of the input camera, the resolution of the output display, the clarity of the output display, and the amount of picture element (pixel) averaging that is used in a given display. The invention supports all of these functions to provide capabilities associated with traditional mechanical pan (through 180 degrees), tilt (through 180 degrees), rotation (through 360 degrees), and zoom devices. The digital system also supports image intensity scaling that emulates the functionality of a mechanical iris by shifting the intensity of the displayed image based on commands from the user or an external computer.

[0030] The postulates and equations that follow are based on the present invention utilizing a fisheye lens as the optical element. There are two basic properties and two basic postulates that describe the perfect fisheye lens system. The first property of a fisheye lens is that the lens has a 2π steradian field-of-view and the image it produces is a circle. The second property is that all objects in the field-of-view are in focus, i.e. the perfect fisheye lens has an infinite depth-of-field. The two important postulates of the fisheye lens system (refer to Figures 4 and 5) are stated as follows:

Postulate 1: Azimuth angle invariability - For object points that lie in a content plane that is perpendicular to the image plane and passes through the image plane origin, all such points are napped as image points onto the line of intersection between the image plane and the content plane, i.e. along a radial line. The azimuth angle of the image points is therefore invariant to elevation and object distance changes within the content plane.

Postulate 2: Equidistant Projection Rule - The radial distance, r, from the image plane origin along the azimuth angle containing the projection of the object point is linearly proportional to the zenith angle β, where β is defined as the angle between a perpendicular line through the image plane origin and the line from the image plane origin to the object point. Thus the relationship:

$$r = k\beta \tag{1}$$

[0031] Using these properties and postulates as the foundation of the fisheye lens system, the mathematical transformation for obtaining a perspective corrected image can be determined. FIG. 4 shows the coordinate reference frames for the object plane and the image plane. The coordinates u,v describe object points within the object plane. The coordinates x,y,z describe points within the image coordinate frame of reference.

[0032] The object plane shown in FIG. 4 is a typical region of interest to determine the napping relationship onto the image plane to properly correct the object. The direction of view vector, DOV[x,y,z], determines the zenith and azimuth angles for mapping the object plane, UV, onto the image plane, XY. The object plane is defined to be perpendicular to the vector, DOV[x,y,z].

[0033] The location of the origin of the object plane in terms of the image plane [x,y,z] in spherical coordinates is given by:

$$x = D \sin\beta \cos\partial$$

$$y = D \sin\beta \sin\partial$$

$$z = D \cos\beta \tag{2}$$

where D = scalar length from the image plane origin to the object plane origin, β is the zenith angle, and ∂ is the azimuth angle in image plane spherical coordinates. The origin of object plane is represented as a vector using the components given in equation 1 as:

$$DOV[x,y,z] = [D\sin\beta\cos\partial,\ D\sin\beta\sin\partial,\ D\cos\beta] \tag{3}$$

[0034] DOV[x,y,z] is perpendicular to the object plane and its scalar magnitude D provides the distance to the object plane. By aligning the YZ plane with the direction of action of DOV[x,y,z], the azimuth angle ∂ becomes either 90 or 270 degrees and therefore the x component becomes zero resulting in the DOV[x,y,z] coordinates:

$$DOV[x,y,z] = [0,\ -D\sin\beta,\ D\cos\beta] \tag{4}$$

[0035] Referring now to FIG. 5, the object point relative to the UV plane origin in coordinates relative to the origin of the image plane is given by the following:

$$x = u$$

$$y = v \cos\beta$$

$$z = v \sin\beta \tag{5}$$

therefore, the coordinates of a point P(u,v) that lies in the object plane can be represented as a vector P[x,y,z] in image plane coordinates:

$$P[x,y,z] = [u,\ v\cos\beta,\ v\sin\beta] \tag{6}$$

where P[x,y,z] describes the position of the object point in image coordinates relative to the origin of the UV plane. The object vector o[x,y,z] that describes the object point in image coordinates is then given by:

$$O[x,y,z] = DOV[x,y,z] + P[x,y,z] \tag{7}$$

$$O[x,y,z] = [u, v\cos\beta - D\sin\beta, v\sin\beta + D\cos\beta] \tag{8}$$

[0036] Projection onto a hemisphere of radius R attached to the image plane is determined by scaling the object vector o[x,y,z] to produce a surface vector s[x,y,z]:

$$S[x,y,z] = \frac{RO[x,y,z]}{|O[x,y,z]|} \tag{9}$$

[0037] By substituting for the components of O[x,y,z] from Equation 8, the vector S[x,y,z] describing the image point mapping onto the hemisphere becomes:

$$S[x,y,z] = \frac{RO[u, (v\cos\beta - D\sin\beta), (v\sin\beta + D\cos\beta)]}{\sqrt{u^2+(v\cos\beta - D\sin\beta)^2, (v\sin\beta + D\cos\beta)^2}} \tag{10}$$

[0038] The denominator in Equation 10 represents the length or absolute value of the vector O[x,y,z] and can be simplified through algebraic and trigonometric manipulation to give:

$$S[x,y,z] = \frac{RO[u, (v\cos\beta - D\sin\beta), (v\sin\beta + D\cos\beta)]}{\sqrt{u^2+v^2+D^2}} \tag{11}$$

[0039] From equation 11, the mapping onto the two-dimensional image plane can be obtained for both x and y as:

$$x = \frac{Ru}{\sqrt{u^2+v^2+D^2}} \tag{12}$$

$$y = \frac{R(v\cos\beta - D\sin\beta)}{\sqrt{u^2+v^2+D^2}} \tag{13}$$

[0040] Additionally, the image plane center to object plane distance D can be represented in terms of the fisheye image circular radius R by the relation:

$$D=mR \tag{14}$$

where m represents the scale factor in radial units R from the image plane origin to the object plane origin. Substituting Equation 14 into Equations 12 and 13 provides a means for obtaining an effective scaling operation or magnification which can be used to provide zoom operation.

$$x = \frac{Ru}{\sqrt{u^2+v^2+m^2R^2}} \tag{15}$$

$$y = \frac{R(v\cos\beta - mR\sin\beta)}{\sqrt{u^2+v^2+m^2R^2}} \tag{16}$$

[0041] Using the equations for two-dimensional rotation of axes for both the UV object plane and the XY image plane the last two equations can be further manipulated to provide a more general set of equations that provides for rotation within the image plane and rotation within the object plane.

$$x = \frac{R[uA-vB+mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}} \tag{17}$$

$$y = \frac{R[uC-vD+mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}} \quad (18)$$

where:

$$A = (\cos\varnothing\cos\partial - \sin\varnothing\sin\partial\cos\beta)$$

$$B = (\sin\varnothing\cos\partial + \cos\varnothing\sin\partial\cos\beta)$$

$$C = (\cos\varnothing\sin\partial + \sin\varnothing\cos\partial\cos\beta)$$

$$D = (\sin\varnothing\sin\partial - \cos\varnothing\cos\partial\cos\beta) \quad (19)$$

and where:

R = radius of the image circle
β = zenith angle
∂ = Azimuth angle in image plane
$\varnothing$ = Object plane rotation angle
m = Magnification
u,v = object plane coordinates
x,y = image plane coordinates

[0042] The Equations 17 and 18 provide a direct mapping from the UV space to the XY image space and are the fundamental mathematical result that supports the functioning of the present omnidirectional viewing system with no moving parts. By knowing the desired zenith, azimuth, and object plane rotation angles and the magnification, the locations of x and y in the imaging array can be determined. This approach provides a means to transform an image from the input video buffer to the output video buffer exactly. Also, the fisheye image system is completely symmetrical about the zenith, therefore, the vector assignments and resulting signs of various components can be chosen differently depending on the desired orientation of the object plane with respect to the image plane. In addition, these postulates and mathematical equations can be modified for various lens elements as necessary for the desired field-of-view coverage in a given application.

[0043] The input means defines the zenith angle, β, the azimuth angle, ∂, the object rotation, $\varnothing$, and the magnification, m. These values are substituted into Equations 19 to determine values for substitution into Equations 17 and 18. The image circle radius, R, is a fixed value that is determined by the camera lens ane element relationship. The variables u and v vary throughout the object plane determining the values for x and y in the image plane coordinates.

[0044] From the foregoing, it can be seen that a fisheye lens provides a hemispherical view that is captured by a camera. The image is then transformed into a corrected image at a desired pan, tilt, magnification, rotation, and focus based on the desired view as described by a control input. The image is then output to a television display with the perspective corrected. Accordingly, no mechanical devices are required to attain this extensive analysis and presentation of the view of an environment through 180 degrees of pan, 180 degrees of tilt, 360 degrees of rotation, and various degrees of zoom magnification.

Claims

1. A system for providing perspective corrected views of a selected portion of a received optical image captured using a wide angle lens (1), the received optical image being distorted, the system comprising:

    image capture means (3) for receiving signals corresponding to said received optical image and for digitising said signal;
    input image memory means (4) for receiving said digitised signal;
    input means (12,13) for selecting a portion of said received image to view;
    image transform processor means (5) for processing said digitised signals to produce an output signal corresponding to a perspective corrected image of said selected portion of said received image;
    output image memory means (9) for receiving said output signal from said image transform processor means

(5); and
output means (10,11) connected to said output image memory means (9) for recording or displaying said perspective corrected image of said selected portion;

CHARACTERISED IN THAT
said image transform processor means (5) comprises transform parameter calculation means for calculating transform parameters for said selected portion of said image and processes said digitised signal based on said calculated transform parameters to generate said output signal.

2. A system according to claim 1, comprising a camera imaging system (2) for receiving said optical image and for producing said signals corresponding to said received optical image for output to said image capture means (3).

3. A system according to claim 2, comprising wide angle lens means (1) mounted on said camera imaging system for producing said optical image for optical conveyance to said camera imaging system.

4. A system according to claim 3, wherein said lens means is one or more fish-eye lenses (1).

5. A system according to any one of the preceding claims, wherein said input means (12,13) provides for input to said image transform processor means of one or more of: a direction of view; tilting of a viewing angle; rotation of a viewing angle; pan of said viewing angle; focus of said image and magnification of the selected portion of the image.

6. A system according to claim 5, wherein tilting of said viewing angle through at least 180 degrees is provided for.

7. A system according to claim 5 or claim 6, wherein rotation of said viewing angle through 360 degrees is provided for.

8. A system according to any one of claims 5 to 7, wherein pan of said viewing angle through at least 180 degrees is provided for.

9. A system according to claim 8, wherein pan of said viewing angle through 360 degrees is provided for.

10. A system according to any one of the preceding claims, wherein said input means is a user-operated manipulator switch means (12).

11. A system according to any one of claims 1 to 9, wherein said input means is a signal from a computer input means (13).

12. A system according to any one of the preceding claims, wherein said image transform processing means (5) is programmed to implement the following two equations:

$$x = \frac{R\{uA-vB+mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R\{uC-vD+mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

where:

$$A = (\cos\phi\cos\delta - \sin\phi\sin\delta\cos\beta)$$

$$B = (\sin\phi\cos\delta + \cos\phi\sin\delta\cos\beta)$$

$$C = (\cos\phi\sin\delta + \sin\phi\cos\delta\cos\beta)$$

$$D = (\sin\phi\sin\delta + \cos\phi\cos\delta\cos\beta)$$

and where:

R = radius of the image circle
β = zenith angle
δ = Azimuth angle in image plane
ϕ = Object plane rotation angle
m = Magnification
u,v = object plane coordinates
x,y = image plane coordinates

13. A method for providing perspective corrected views of a selected portion of an optical image captured with a wide angle lens (1), the received optical image being distorted, the method comprising:

providing a digitised signal corresponding to said optical image;
selecting a portion of said optical image;
transforming said digitised signal to produce an output signal corresponding to a perspective corrected image of said selected portion of said received image; and
displaying or recording said perspective corrected image of said selected portion;

CHARACTERISED IN THAT
said step of transforming said digitised signal comprises calculating transform parameters for said selected portion of said image, said calculated transform parameters being used to control said transformation of the digitised signal to generate said output signal.

14. A method according to claim 13, comprising first receiving said optical image, producing signals corresponding to said received optical image and digitizing said signals.

15. A method according to claim 13 or 14, comprising capturing said optical image with one or more fish-eye lenses (1).

16. A method according to any one of claims 13 to 15, wherein said step of selecting the portion of the image to view comprises selecting one or more of: a direction of view; tilting of a viewing angle; rotation of a viewing angle; pan of said viewing angle; focus of said image and magnification of the selected portion of the image.

17. A method according to claim 16, wherein tilting of said viewing angle through at least 180 degrees is provided for.

18. A method according to claim 16 or claim 17, wherein rotation of said viewing angle through 360 degrees is provided for.

19. A method according to any one of claims 16 to 18, wherein pan of said viewing angle through at least 180 degrees is provided for.

20. A method according to claim 19, wherein pan of said viewing angle through 360 degrees is provided for.

21. A method according to any one of claims 13 to 20, wherein said selection of said portion of the image to view is achieved using a user-operated manipulator switch means (12).

22. A method according to any one of claims 13 to 20, wherein said selection of said portion of the image to view is controlled by a signal from a computer input means (13).

23. A method according to any one of claims 13 to 22, wherein said image transformation implements the following two equations:

$$x = \frac{R\{uA - vB + mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R\{uC-vD+mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

where:

$$A = (\cos\phi\cos\delta - \sin\phi\sin\delta\cos\beta)$$

$$B = (\sin\phi\cos\delta + \cos\phi\sin\delta\cos\beta)$$

$$C = (\cos\phi\sin\delta + \sin\phi\cos\delta\cos\beta)$$

$$D = (\sin\phi\sin\delta + \cos\phi\cos\delta\cos\beta)$$

and where:

R = radius of the image circle
β = zenith angle
δ = Azimuth angle in image plane
ϕ = Object plane rotation angle
m = Magnification
u,v = object plane coordinates
x,y = image plane coordinates

24. A method according to any one of claims 13 to 23, wherein a plurality of portions of said image are selected for viewing and are displayed either simultaneously or consecutively.

25. A method according to any one of claims 13 to 24, wherein the image is viewed interactively by repeating the steps of selecting, transforming and displaying said portion of the image.

26. A method according to claim 13, wherein said step of transforming the image is based on lens characteristics of the wide angle lens (1).

27. A method according to claim 26, wherein the step of transformation is based on azimuth angle invariability and equidistant projection.

28. A method according to claim 13, wherein the step of transforming the image is performed at real time video rates.

Patentansprüche

1. System zum Vorsehen perspektivisch korrigierter Ansichten eines ausgewählten Teils eines empfangenen optischen Bildes, das mit einer Weitwinkellinse (1) aufgenommen ist, wobei das empfangene optische Bild verzerrt ist, mit folgenden Merkmalen:

eine Bilderfassungseinrichtung (3) zum Empfangen von Signalen, welche dem empfangenen optischen Bild entsprechen, und zum Digitalisieren des Signals;

eine Eingangsbildspeichereinrichtung (4) zum Empfangen des digitalisierten Signals;

eine Eingabeeinrichtung (12, 13) zum Auswählen eines Teils des empfangenen Bildes für die Betrachtung;

eine Bildtransformationsverarbeitungseinrichtung (5) zum Verarbeiten der digitalisierten Signale zum Erzeugen eines Ausgangssignals, welches einem perspektivisch korrigierten Bild des ausgewählten Teils des emp-

fangenen Bildes entspricht;

eine Ausgangsbildspeichereinrichtung (9) zum Empfangen des Ausgangssignals von der Bildtransformationsverarbeitungseinrichtung (5); und

eine Ausgabeeinrichtung (10, 11), die mit der Ausgangsbildspeichereinrichtung (9) verbunden ist, zum Aufzeichnen oder Anzeigen des perspektivisch korrigierten Bildes des ausgewählten Teils;

dadurch gekennzeichnet,daß
die Bildtransformationsverarbeitungseinrichtung (5) eine Transformationsparameterrecheneinrichtung zum Berechnen von Transformationsparametern für den ausgewählten Teil des Bildes umfaßt und das digitalisierte Signal gestützt auf die berechneten Transformationsparameter verarbeitet, um das Ausgangssignal zu erzeugen.

2. System nach Anspruch 1, mit einem Kameraabbildungssystem (2) zum Empfangen des optischen Bildes und zum Erzeugen der Signale, welche dem empfangenen optischen Bild entsprechen, zur Ausgabe an die Bilderfassungseinrichtung (3).

3. System nach Anspruch 2, mit einer Weitwinkellinseneinrichtung (1), die an dem Kameraabbildungssystem angebracht ist, zum Erzeugen des optischen Bildes für die optische Übertragung an das Kameraabbildungssystem.

4. System nach Anspruch 3, wobei die Linseneinrichtung eine oder mehrere Fischaugen-Linsen (1) umfaßt.

5. System nach einem der vorangehenden Ansprüche, wobei die Eingabeeinrichtung (12, 13) eine Eingabe für die Bildtransformationsverarbeitungseinrichtung aus einem oder mehreren der folgenden vorsieht: Blickrichtung; Neigung eines Blickwinkels; Drehung eines Blickwinkels; Schwenken des Blickwinkels; Brennpunkt des Bildes und Vergrößerung des ausgewählten Teiles des Bildes.

6. System nach Anspruch 5, wobei das Neigen des Blickwinkels um wenigstens 180° vorgesehen ist.

7. System nach Anspruch 5 oder Anspruch 6, wobei die Drehung des Blickwinkels um 360° vorgesehen ist.

8. System nach einem der Ansprüche 5 bis 7, wobei das Schwenken des Blickwinkels um wenigstens 180° vorgesehen ist.

9. System nach Anspruch 8, wobei das Schwenken des Blickwinkels um 360° vorgesehen ist.

10. System nach einem der vorangehenden Ansprüche, wobei die Eingabeeinrichtung eine von einem Benutzer bedienbare Einstell-Schalteinrichtung (12) ist.

11. System nach einem der Ansprüche 1 bis 9, wobei die Eingabeeinrichtung ein Signal von einer Computereingabeeinrichtung (13) vorsieht.

12. System nach einem der vorangehenden Ansprüche, wobei die Bildtransformationsverarbeitungseinrichtung (5) programmiert ist, um die folgenden zwei Gleichungen zu realisieren

$$x = \frac{R[uA - vB + mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R[uC - vD + mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}}$$

wobei

$$A = (\cos\varnothing\cos\partial - \sin\varnothing\sin\partial\cos\beta)$$

$$B = (\sin\varnothing\cos\partial + \cos\varnothing\,\sin\partial\cos\beta)$$

$$C = (\cos\varnothing\sin\partial + \sin\varnothing\cos\partial\cos\beta)$$

$$D = (\sin\varnothing\sin\partial + \cos\varnothing\cos\partial\cos\beta)$$

und wobei

R = Radius des Bildkreises
β = Zenitwinkel
∂ = Azimuthwinkel in Bildebene
$\varnothing$ = Drehwinkel der Objektebene
m = Vergrößerung
u, v = Koordinaten in Objektebene
x, y = Koordinaten in Bildebene.

13. Verfahren zum Vorsehen perspektivisch korrigierter Ansichten eines ausgewählten Teils eines optischen Bildes, das mit einer Weitwinkellinse (1) erfaßt wird, wobei das empfangene optische Bild verzerrt ist, mit folgenden Verfahrensschritten:

Vorsehen eines digitalisierten Signals, das dem optischen Bild entspricht;

Auswählen eines Teils des optischen Bildes;

Transformieren des digitalisierten Signals zum Erzeugen eines Ausgangssignals, das einem perspektivisch korrigierten Bild des ausgewählten Teils des empfangenen Bildes entspricht; und

Anzeigen oder Aufzeichnen des perspektivisch korrigierten Bildes des ausgewählten Teils;

dadurch gekennzeichnet, daß
der Schritt des Transformierens des digitalen Signals das Berechnen von Transformationsparametern für den ausgewählten Teil des Bildes umfaßt, wobei die berechneten Transformationsparameter dazu verwendet werden, die Transformation des digitalisierten Signals zum Erzeugen des Ausgangssignals zu steuern.

14. Verfahren nach Anspruch 13, bei dem zuerst das optische Bild empfangen und Signale erzeugt werden, welche dem empfangenen optischen Bild entsprechen, und diese Signale digitalisiert werden.

15. Verfahren nach Anspruch 13 oder 14, bei dem das optische Bild mit einer oder mehreren Fischaugen-Linsen (1) erfaßt wird.

16. Verfahren nach einem der Ansprüche 13 bis 15, wobei der Schritt des Auswählens des Teils bis zur Betrachtung des Bildes das Auswählen eines oder mehrerer der folgenden umfaßt: Blickrichtung; Neigung eines Blickwinkels; Drehung eines Blickwinkels; Schwenken des Blickwinkels; Brennpunkt des Bildes und Vergrößerung des ausgewählten Teiles des Bildes.

17. Verfahren nach Anspruch 16, wobei der Blickwinkel um wenigstens 180° geneigt werden kann.

18. Verfahren nach Anspruch 16 oder Anspruch 17, wobei der Blickwinkel um 360° gedreht werden kann.

19. Verfahren nach einem der Ansprüche 16 bis 18, wobei der Blickwinkel um wenigstens 180° geschwenkt werden kann.

20. Verfahren nach Anspruch 19, wobei der Blickwinkel um 360° geschwenkt werden kann.

21. Verfahren nach einem der Ansprüche 13 bis 20, wobei das Auswählen des Teils des zu betrachtenden Bildes

mittels einer von einem Benutzer bedienten Einstell-Schalteinrichtung (12) durchgeführt wird.

22. Verfahren nach einem der Ansprüche 13 bis 20, wobei das Auswählen des Teils des zu betrachtenden Bildes durch ein Signal von einer Computereingabeeinrichtung (13) gesteuert wird.

23. Verfahren nach einem der Ansprüche 13 bis 22, wobei die Bildtransformation die folgenden zwei Gleichungen realisiert:

$$x = \frac{R[uA - vB + mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R[uC - vD + mR\sin\beta\sin\partial]}{\sqrt{u^2+v^2+m^2R^2}}$$

wobei

$$A = (\cos\varnothing\cos\partial - \sin\varnothing\sin\partial\cos\beta)$$

$$B = (\sin\varnothing\cos\partial + \cos\varnothing\sin\partial\cos\beta)$$

$$C = (\cos\varnothing\sin\partial + \sin\varnothing\cos\partial\cos\beta)$$

$$D = (\sin\varnothing\sin\partial + \cos\varnothing\cos\partial\cos\beta)$$

und wobei

R = Radius des Bildkreises
β = Zenitwinkel
∂ = Azimuthwinkel in Bildebene
Ø = Drehwinkel der Objektebene
m = Vergrößerung
u, v = Koordinaten in Objektebene
x, y = Koordinaten in Bildebene.

24. Verfahren nach einem der Ansprüche 13 bis 23, wobei mehrere Teile des Bildes für die Betrachtung ausgewählt und entweder gleichzeitig oder nacheinander angezeigt werden.

25. Verfahren nach einem der Ansprüche 13 bis 24, wobei das Bild interaktiv betrachtet wird, indem die Schritte des Auswählens, Transformierens und Anzeigen des Teiles des Bildes wiederholt werden.

26. Verfahren nach Anspruch 13, wobei der Schritt des Transformierens des Bildes auf Linseneigenschaften der Weitwinkellinse (1) basiert.

27. Verfahren nach Anspruch 26, wobei der Schritt des Transformierens auf einer Invariabilität des Azimuthwinkels und einer äquidistanten Projektion basiert.

28. Verfahren nach Anspruch 13, wobei der Schritt des Transformierens des Bildes mit Realzeit-Videoraten durchgeführt wird.

Revendications

1. Système permettant de fournir des vues corrigées en perspective d'une partie choisie d'une image optique reçue capturée à l'aide d'un objectif grand angulaire (1), l'image optique reçue étant déformée, le système comprenant :

    des moyens de capture d'image (3) permettant de recevoir des signaux correspondant à ladite image optique reçue et permettant de numériser ledit signal ;
    des moyens de mémoire d'image d'entrée (4) permettant de recevoir le signal numérisé ;
    des moyens d'entrée (12, 13) permettant de choisir une partie de ladite image reçue à visualiser ;
    des moyens de processeur de transformation d'image (5) permettant de traiter lesdits signaux numérisés afin de produire un signal de sortie correspondant à une image corrigée en perspective de ladite partie choisie de ladite image reçue ;
    des moyens de mémoire d'image de sortie (9) permettant de recevoir ledit signal de sortie desdits moyens de processeur de transformation d'image (5) ; et
    des moyens de sortie (10, 11) reliés aux dits moyens de mémoire d'image de sortie (9) permettant d'enregistrer ou de montrer ladite image corrigée en perspective de ladite partie choisie ;

    CARACTÉRISÉ EN CE QUE
    lesdits moyens de processeur de transformation d'image (5) comprennent des moyens de calcul de paramètres de transformation permettant de calculer les paramètres de transformation de ladite partie choisie de ladite image, et traitent ledit signal numérisé sur la base desdits paramètres de transformation calculés afin de produire ledit signal de sortie.

2. Système selon la revendication 1, comprenant un système de formation d'image par caméra (2) permettant de recevoir ladite image optique et de produire lesdits signaux correspondant à ladite image optique reçue, à destination desdits moyens de capture d'image (3).

3. Système selon la revendication 2, comprenant des moyens d'objectif grand angulaire (1) montés sur ledit système de formation d'image par caméra afin de produire ladite image optique pour un transfert optique vers ledit système de formation d'image par caméra.

4. Système selon la revendication 3, dans lequel lesdits moyens d'objectif sont constitués de un ou de plusieurs objectifs ultra grand angulaires (1).

5. Système selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens d'entrée (12, 13) fournissent à l'entrée desdits moyens de processeur de transformation d'image, l'un des éléments suivants, ou plusieurs d'entre eux : une direction de visée ; l'inclinaison d'un angle de visée ; la rotation d'un angle de visée ; le panoramique dudit angle de visée ; la mise au point de ladite image et le grossissement de la partie choisie de l'image.

6. Système selon la revendication 5, dans lequel l'inclinaison dudit angle de visée est prévue sur au moins 180 °.

7. Système selon l'une quelconque des revendications 5 ou 6, dans lequel la rotation dudit angle de visée est prévue sur 360 °.

8. Système selon l'une quelconque des revendications 5 à 7, dans lequel le panoramique dudit angle de visée est prévu sur au moins 180 °.

9. Système selon la revendication 8, dans lequel le panoramique dudit angle de visée est prévu sur 360 °.

10. Système selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens d'entrée sont des moyens de commutateur de manipulateur actionnés par l'utilisateur (12).

11. Système selon l'une quelconque des revendications 1 à 9, dans lequel lesdits moyens d'entrée sont un signal issu des moyens d'entrée d'ordinateur (13).

12. Système selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens de traitement de transformation d'image (5) sont programmés afin de mettre en application les deux équations suivantes :

$$x = \frac{R\{uA - vB + mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R\{uC - vD + mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

où:

$$A = (\cos\Phi\cos\delta - \sin\Phi\sin\delta\cos\beta)$$

$$B = (\sin\Phi\cos\delta - \cos\Phi\sin\delta\cos\beta)$$

$$C = (\cos\Phi\sin\delta - \sin\Phi\cos\delta\cos\beta)$$

$$D = (\sin\Phi\sin\delta - \cos\Phi\cos\delta\cos\beta)$$

et où :

R = rayon du cercle image
β = angle zénithal
δ = angle azimutal dans le plan image
Φ = angle de rotation du plan objet
m = grossissement
u, v = coordonnées du plan objet
x, y = coordonnées du plan image

13. Procédé permettant de fournir des vues corrigées en perspective d'une partie choisie d'une image optique capturée à l'aide d'un objectif grand angulaire (1), l'image optique reçue étant déformée, le procédé comprenant :

la fourniture d'un signal numérisé correspondant à ladite image optique ;
le choix d'une partie de ladite image optique ;
la transformation dudit signal numérisé afin de produire un signal de sortie correspondant à une image corrigée en perspective de ladite partie choisie de ladite image reçue ; et
l'affichage ou l'enregistrement de ladite image corrigée en perspective de ladite partie choisie ;

CARACTÉRISÉ EN CE QUE
ladite étape de transformation dudit signal numérisé comprend le calcul de paramètres de transformation de ladite partie choisie de ladite image, lesdits paramètres de transformation calculés étant utilisés afin de commander ladite transformation du signal numérisé afin de produire ledit signal de sortie.

14. Procédé selon la revendication 13, comprenant d'abord la réception de ladite image optique, produisant les signaux correspondant à ladite image optique reçue et numérisant lesdits signaux.

15. Procédé selon l'une quelconque des revendications 13 ou 14, comprenant la capture de ladite image optique avec un ou plusieurs objectifs ultra grand angulaires (1).

16. Procédé selon l'une quelconque des revendications 13 à 15, dans lequel ladite étape de choix de la partie de l'image à voir comprend le choix de l'un des éléments suivants, ou de plusieurs d'entre eux : une direction de visée ; l'inclinaison d'un angle de visée ; la rotation d'un angle de visée ; le panoramique dudit angle de visée ; la mise au point de ladite image et le grossissement de la partie choisie de l'image.

17. Procédé selon la revendication 16, dans lequel l'inclinaison dudit angle de visée est prévue sur au moins 180 °.

18. Procédé selon l'une quelconque des revendications 16 ou 17, dans lequel la rotation dudit angle de visée est prévue sur 360 °.

19. Procédé selon l'une quelconque des revendications 16 à 18, dans lequel le panoramique dudit angle de visée est prévu sur au moins 180 °.

20. Procédé selon la revendication 19, dans lequel le panoramique dudit angle de visée est prévu sur 360 °.

21. Procédé selon l'une quelconque des revendications 13 à 20, dans lequel ledit choix de ladite partie de l'image à voir se fait grâce à des moyens de commutateur de manipulateur actionnés par l'utilisateur (12).

22. Procédé selon l'une quelconque des revendications 13 à 20, dans lequel ledit choix de ladite partie de l'image à voir est commandé par un signal fourni par des moyens d'entrée d'ordinateur (13).

23. Procédé selon l'une quelconque des revendications 13 à 22, dans lequel ladite transformation d'image met en application les deux équations suivantes :

$$x = \frac{R\{uA - vB + mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

$$y = \frac{R\{uC - vD + mR\sin\beta\sin\partial\}}{\sqrt{u^2+v^2+m^2R^2}}$$

où :

$$A = (\cos\Phi\cos\delta - \sin\Phi\sin\delta\cos\beta)$$

$$B = (\sin\Phi\cos\delta - \cos\Phi\sin\delta\cos\beta)$$

$$C = (\cos\Phi\sin\delta - \sin\Phi\cos\delta\cos\beta)$$

$$D = (\sin\Phi\sin\delta - \cos\Phi\cos\delta\cos\beta)$$

et où :

R = rayon du cercle image
β = angle zénithal
δ = angle azimutal dans le plan image
Φ = angle de rotation du plan objet
m = grossissement
u, v = coordonnées du plan objet
x, y = coordonnées du plan image

24. Procédé selon l'une quelconque des revendications 13 à 23, dans lequel une pluralité de parties de ladite image sont choisies pour l'affichage et sont présentées simultanément ou consécutivement.

25. Procédé selon l'une quelconque des revendications 13 à 24, dans lequel l'image est vue de manière interactive en répétant les étapes de choix, de transformation et d'affichage de ladite partie de l'image.

26. Procédé selon la revendication 13, dans lequel ladite étape de transformation de l'image est basée sur les caractéristiques d'objectif de l'objectif grand angulaire (1).

27. Procédé selon la revendication 26, dans lequel l'étape de transformation est basée sur l'invariabilité de l'angle d'azimut et sur la projection équidistante.

28. Procédé selon la revendication 13, dans lequel l'étape de transformation de l'image est réalisée à des vitesses de vidéo en temps réel.

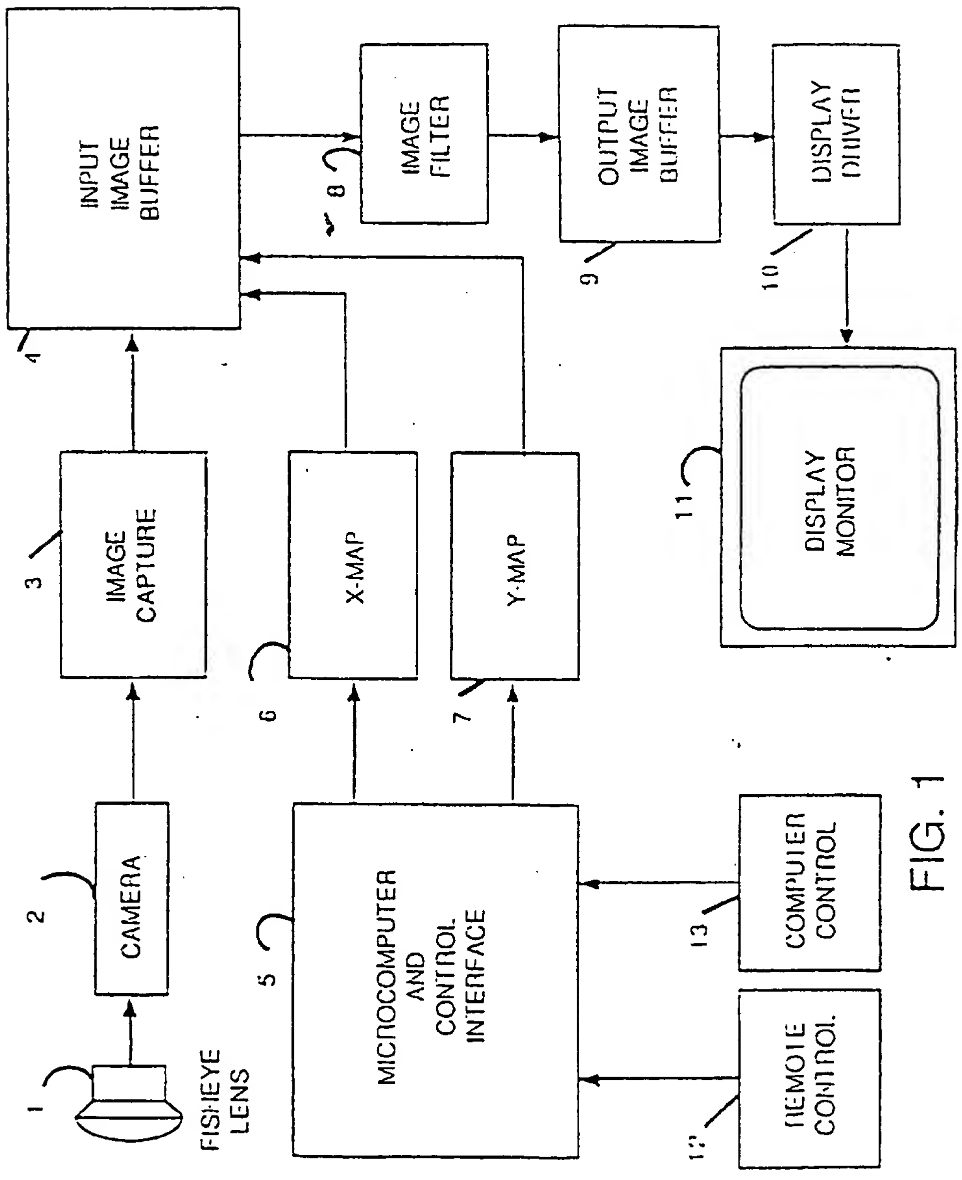
INPUT IMAGE BUFFER
IMAGE FILTER
OUTPUT IMAGE BUFFER
DISPLAY DRIVER
IMAGE CAPTURE
X-MAP
Y-MAP
DISPLAY MONITOR
CAMERA
MICROCOMPUTER AND CONTROL INTERFACE
COMPUTER CONTROL
REMOTE CONTROL
FISHEYE LENS
1
2
3
4
5
6
7
8
9
10
11
12
13

FIG. 1

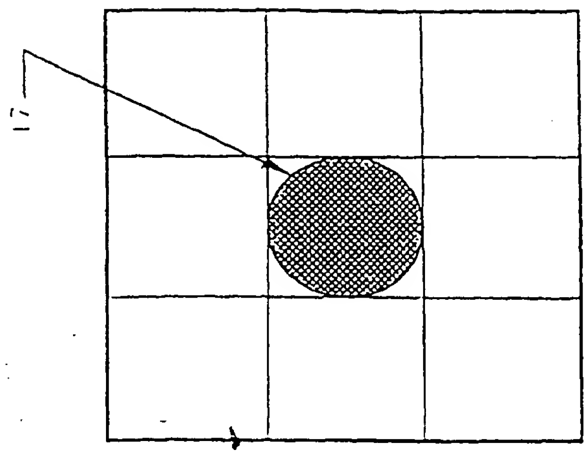

FIG. 3

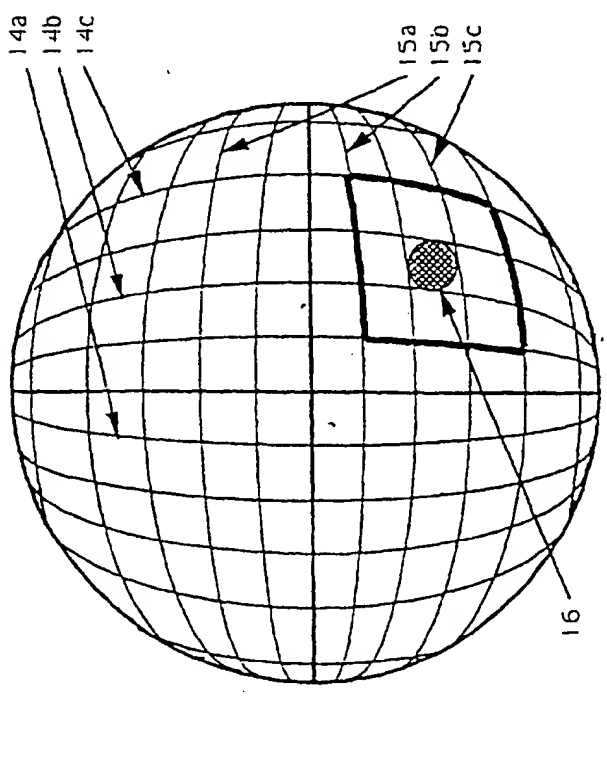

FIG. 2

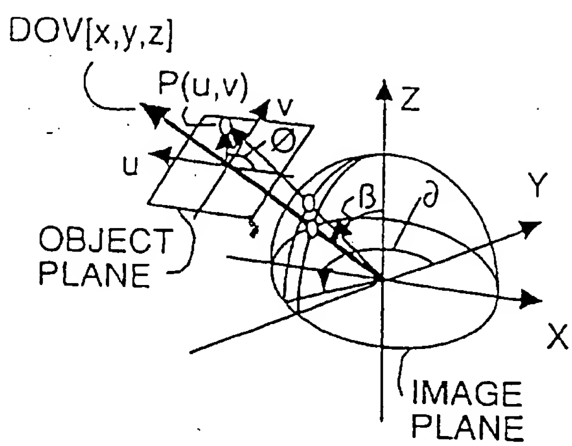

FIG. 4

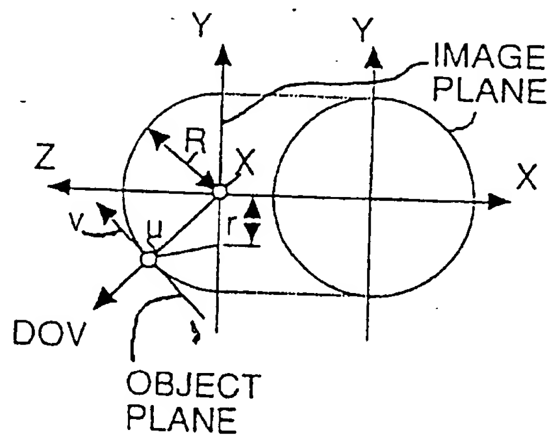

FIG. 5